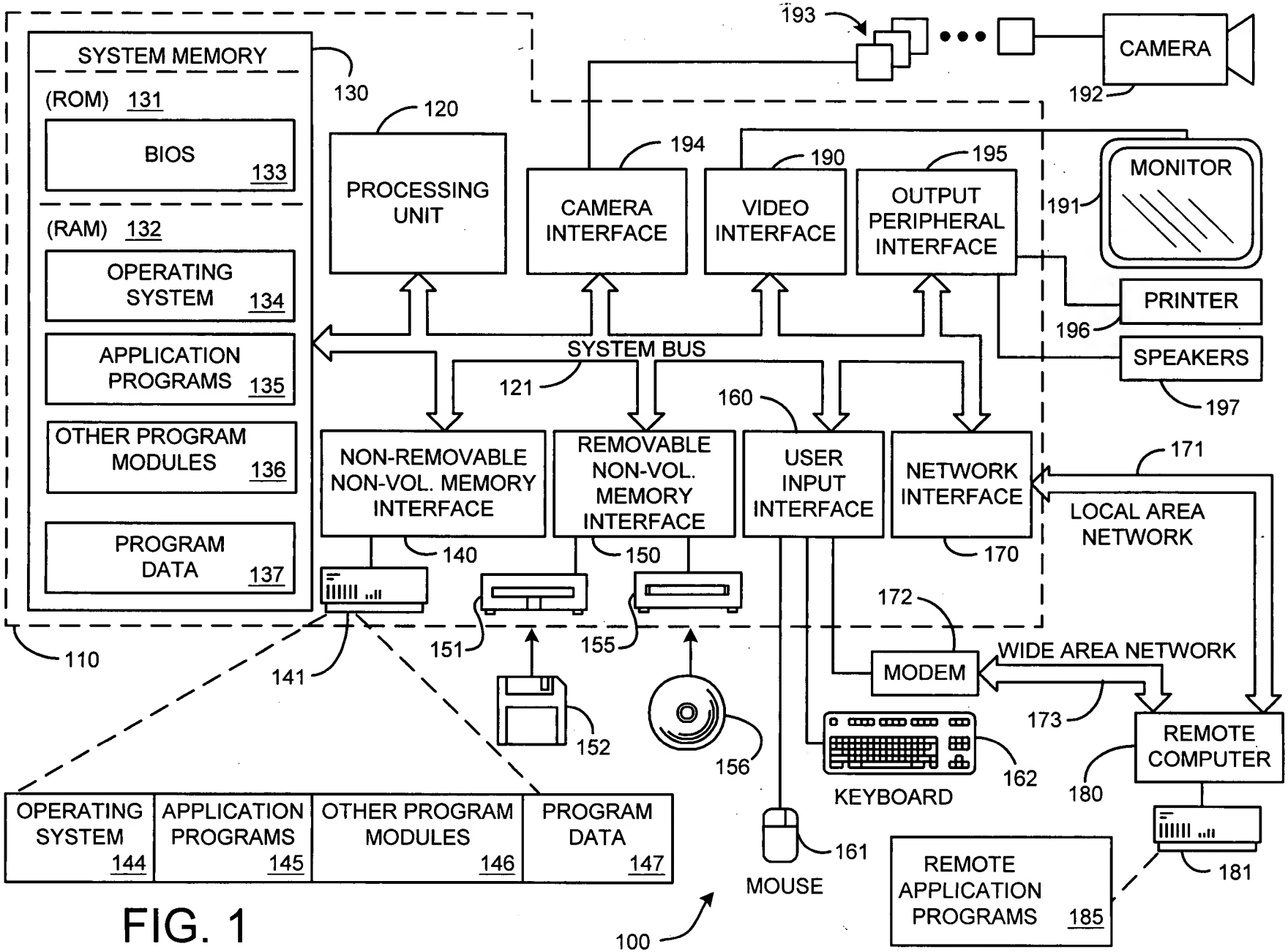

SYSTEM MEMORY
(ROM) 131
BIOS 133
(RAM) 132
OPERATING SYSTEM 134
APPLICATION PROGRAMS 135
OTHER PROGRAM MODULES 136
PROGRAM DATA 137
130
120
PROCESSING UNIT
194
CAMERA INTERFACE
190
VIDEO INTERFACE
195
OUTPUT PERIPHERAL INTERFACE
193
CAMERA
192
MONITOR
191
PRINTER
196
SPEAKERS
197
SYSTEM BUS
121
160
NON-REMOVABLE NON-VOL. MEMORY INTERFACE
140
REMOVABLE NON-VOL. MEMORY INTERFACE
150
USER INPUT INTERFACE
NETWORK INTERFACE
170
171
LOCAL AREA NETWORK
172
MODEM
WIDE AREA NETWORK
173
REMOTE COMPUTER
180
181
110
141
151
155
152
156
KEYBOARD
162
MOUSE
161
REMOTE APPLICATION PROGRAMS 185
OPERATING SYSTEM 144
APPLICATION PROGRAMS 145
OTHER PROGRAM MODULES 146
PROGRAM DATA 147
100

FIG. 1

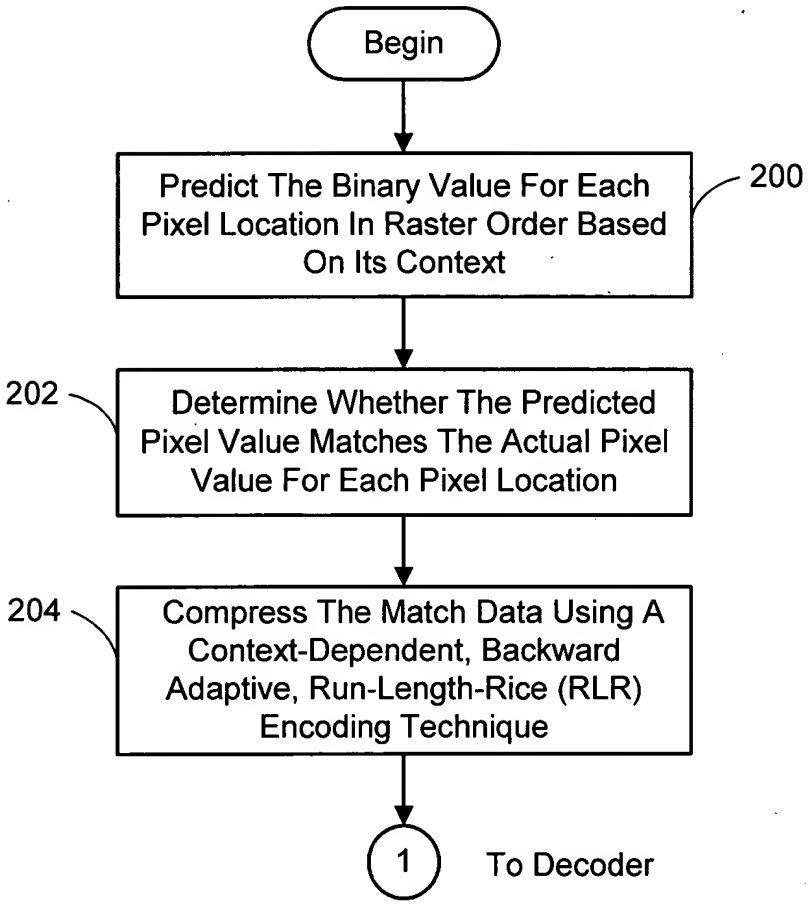

Begin
Predict The Binary Value For Each Pixel Location In Raster Order Based On Its Context
200
202
Determine Whether The Predicted Pixel Value Matches The Actual Pixel Value For Each Pixel Location
204
Compress The Match Data Using A Context-Dependent, Backward Adaptive, Run-Length-Rice (RLR) Encoding Technique
1
To Decoder

FIG. 2A

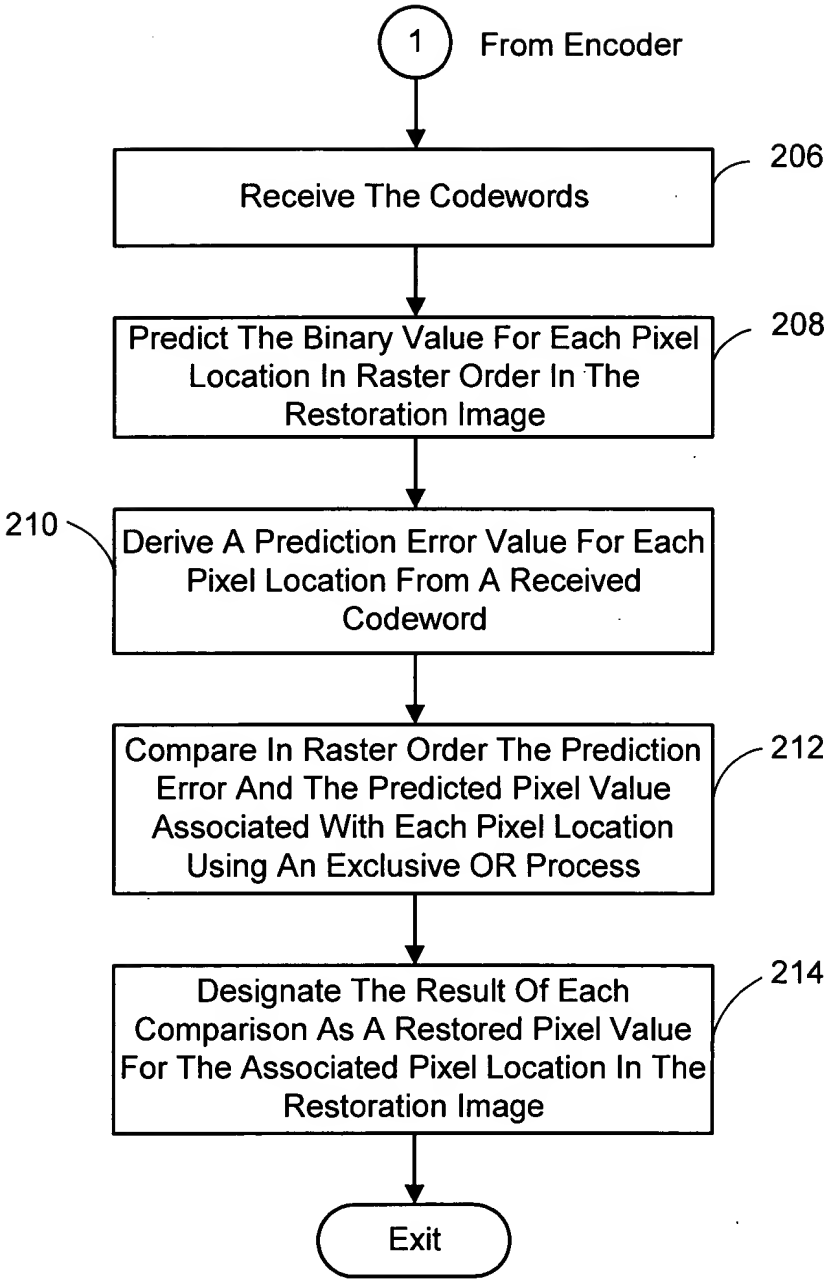

1
From Encoder
Receive The Codewords
206
Predict The Binary Value For Each Pixel Location In Raster Order In The Restoration Image
208
210
Derive A Prediction Error Value For Each Pixel Location From A Received Codeword
Compare In Raster Order The Prediction Error And The Predicted Pixel Value Associated With Each Pixel Location Using An Exclusive OR Process
212
Designate The Result Of Each Comparison As A Restored Pixel Value For The Associated Pixel Location In The Restoration Image
214
Exit

FIG. 2B

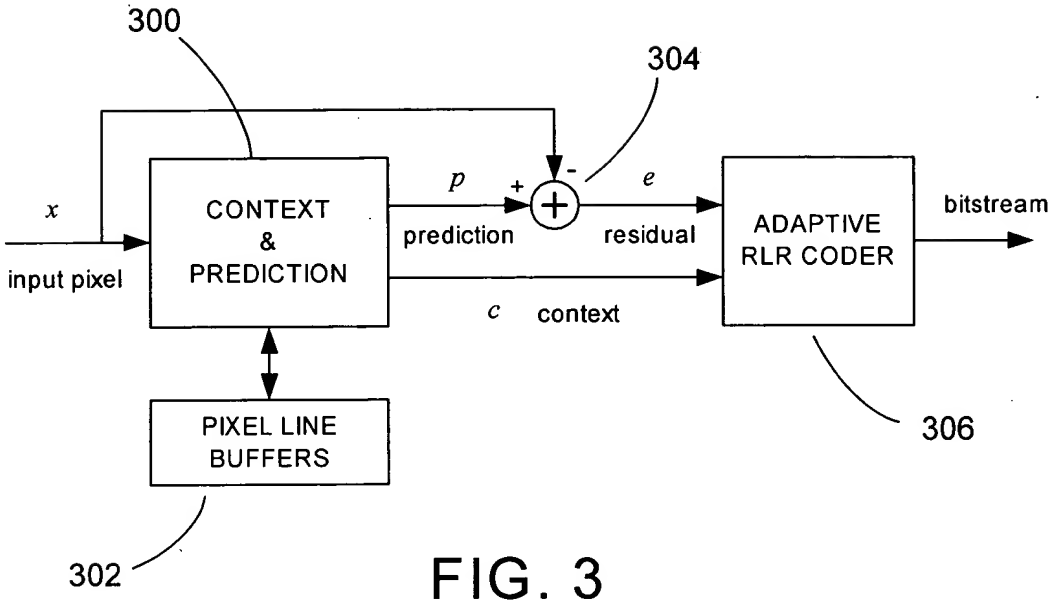

300
304
x
input pixel
CONTEXT
&
PREDICTION
p
prediction
+
-
e
residual
ADAPTIVE
RLR CODER
bitstream
c
context
306
PIXEL LINE
BUFFERS
302

FIG. 3

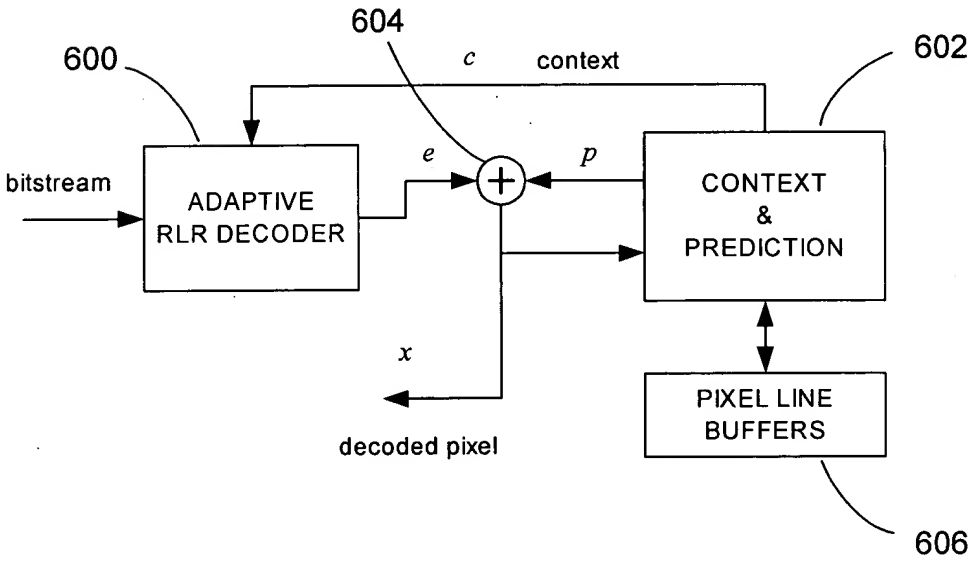

604
600
c
context
602
bitstream
ADAPTIVE
RLR DECODER
e
p
CONTEXT
&
PREDICTION
x
decoded pixel
PIXEL LINE
BUFFERS
606

FIG. 6

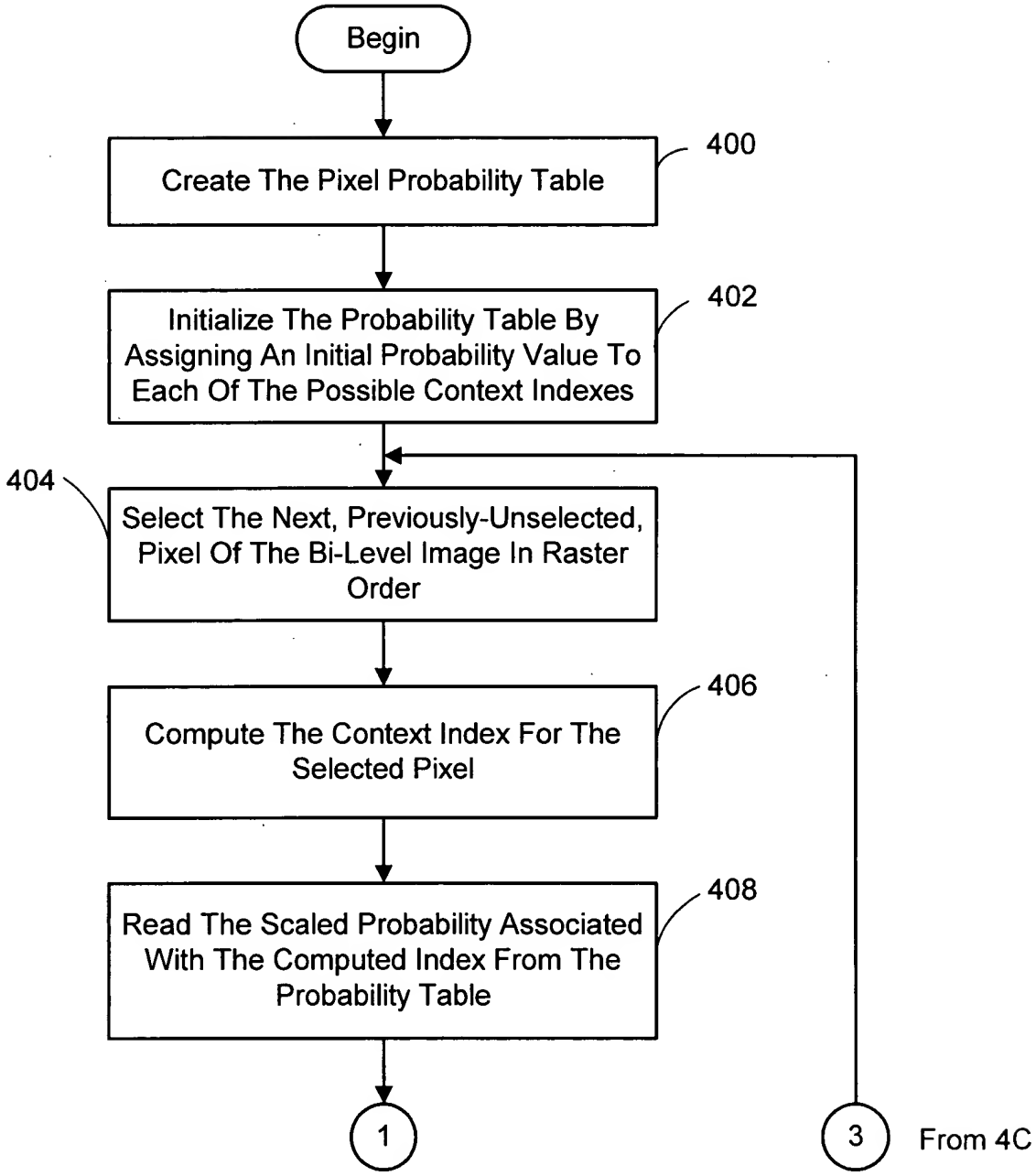

Begin
Create The Pixel Probability Table
400
Initialize The Probability Table By Assigning An Initial Probability Value To Each Of The Possible Context Indexes
402
404
Select The Next, Previously-Unselected, Pixel Of The Bi-Level Image In Raster Order
Compute The Context Index For The Selected Pixel
406
Read The Scaled Probability Associated With The Computed Index From The Probability Table
408
1
3
From 4C

FIG. 4A

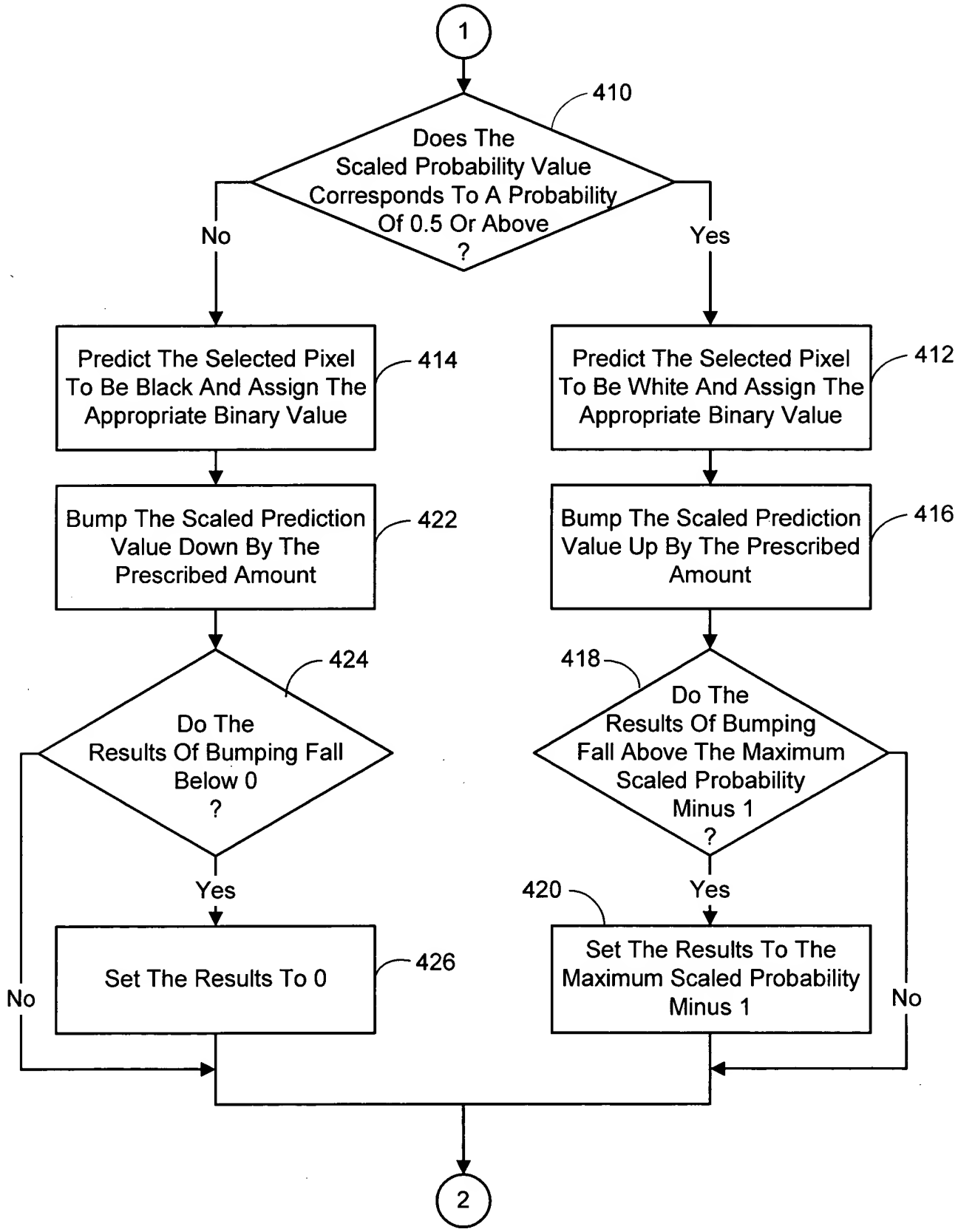

1
410
Does The Scaled Probability Value Corresponds To A Probability Of 0.5 Or Above ?
No
Yes
Predict The Selected Pixel To Be Black And Assign The Appropriate Binary Value
414
Predict The Selected Pixel To Be White And Assign The Appropriate Binary Value
412
Bump The Scaled Prediction Value Down By The Prescribed Amount
422
Bump The Scaled Prediction Value Up By The Prescribed Amount
416
424
Do The Results Of Bumping Fall Below 0 ?
418
Do The Results Of Bumping Fall Above The Maximum Scaled Probability Minus 1 ?
Yes
Yes
420
Set The Results To 0
426
Set The Results To The Maximum Scaled Probability Minus 1
No
No
2

FIG. 4B

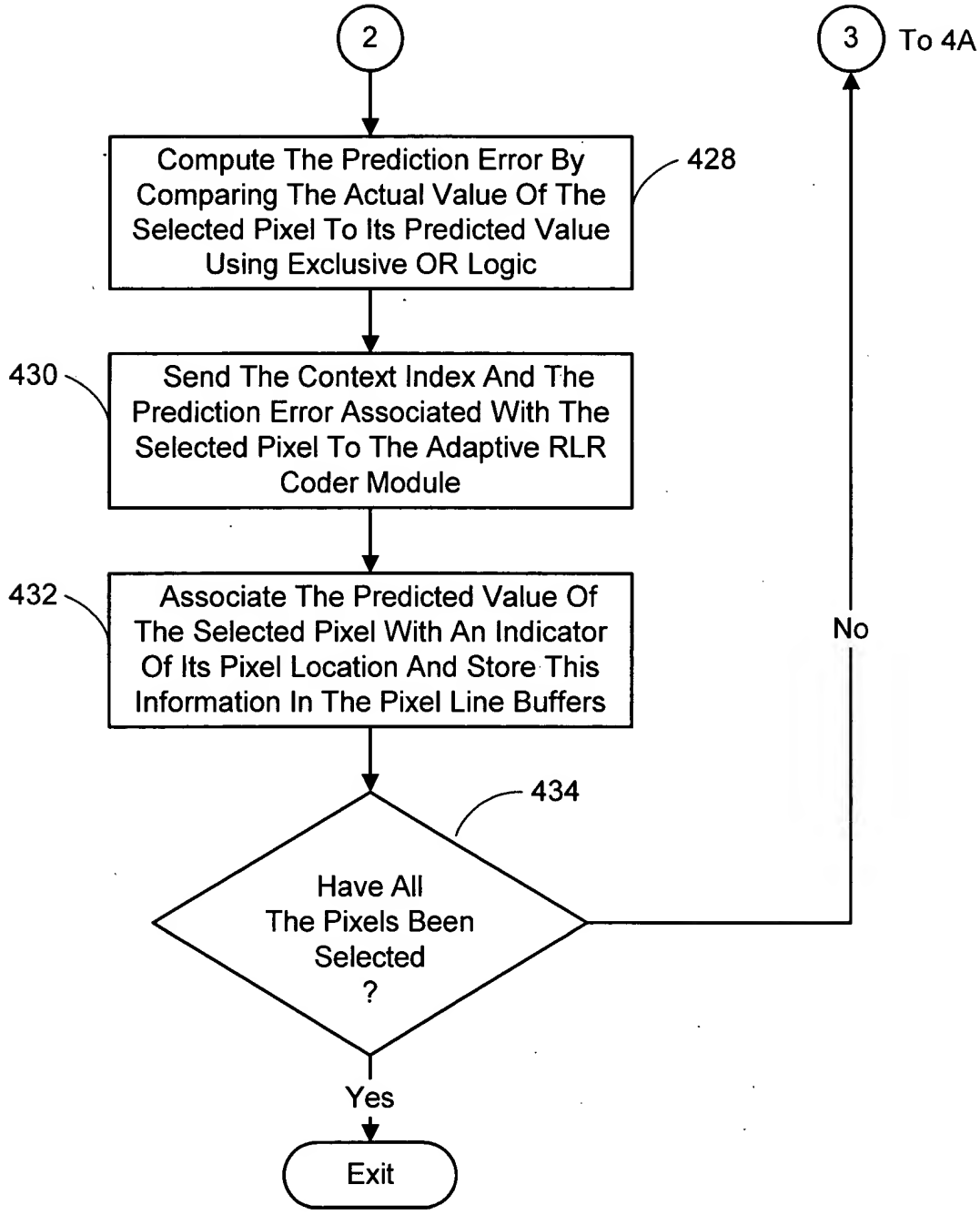

2
3
To 4A
Compute The Prediction Error By Comparing The Actual Value Of The Selected Pixel To Its Predicted Value Using Exclusive OR Logic
428
Send The Context Index And The Prediction Error Associated With The Selected Pixel To The Adaptive RLR Coder Module
430
Associate The Predicted Value Of The Selected Pixel With An Indicator Of Its Pixel Location And Store This Information In The Pixel Line Buffers
432
434
Have All The Pixels Been Selected ?
No
Yes
Exit

FIG. 4C

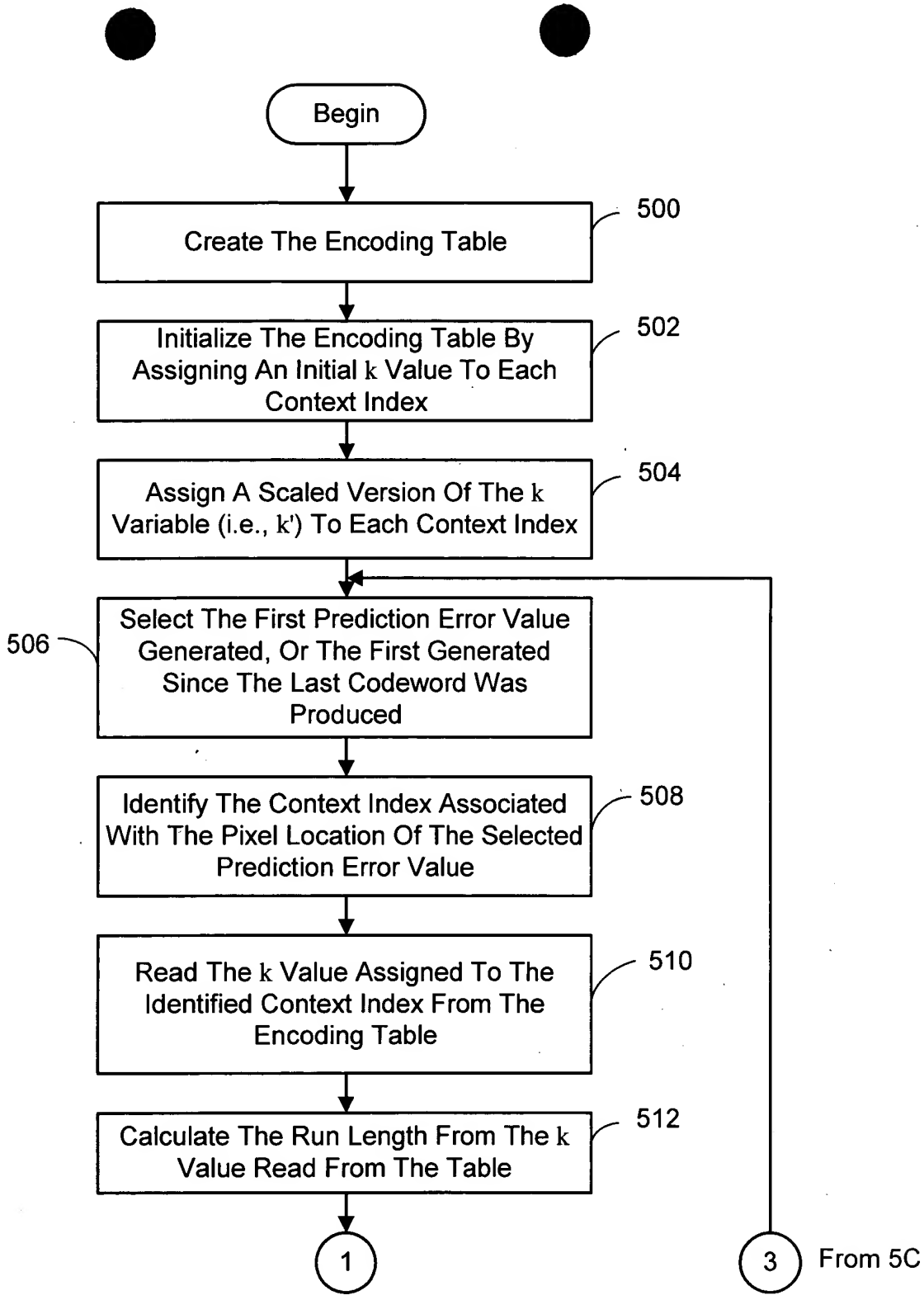

Begin
Create The Encoding Table
500
Initialize The Encoding Table By Assigning An Initial k Value To Each Context Index
502
Assign A Scaled Version Of The k Variable (i.e., k') To Each Context Index
504
Select The First Prediction Error Value Generated, Or The First Generated Since The Last Codeword Was Produced
506
Identify The Context Index Associated With The Pixel Location Of The Selected Prediction Error Value
508
Read The k Value Assigned To The Identified Context Index From The Encoding Table
510
Calculate The Run Length From The k Value Read From The Table
512
1
3
From 5C

FIG. 5A

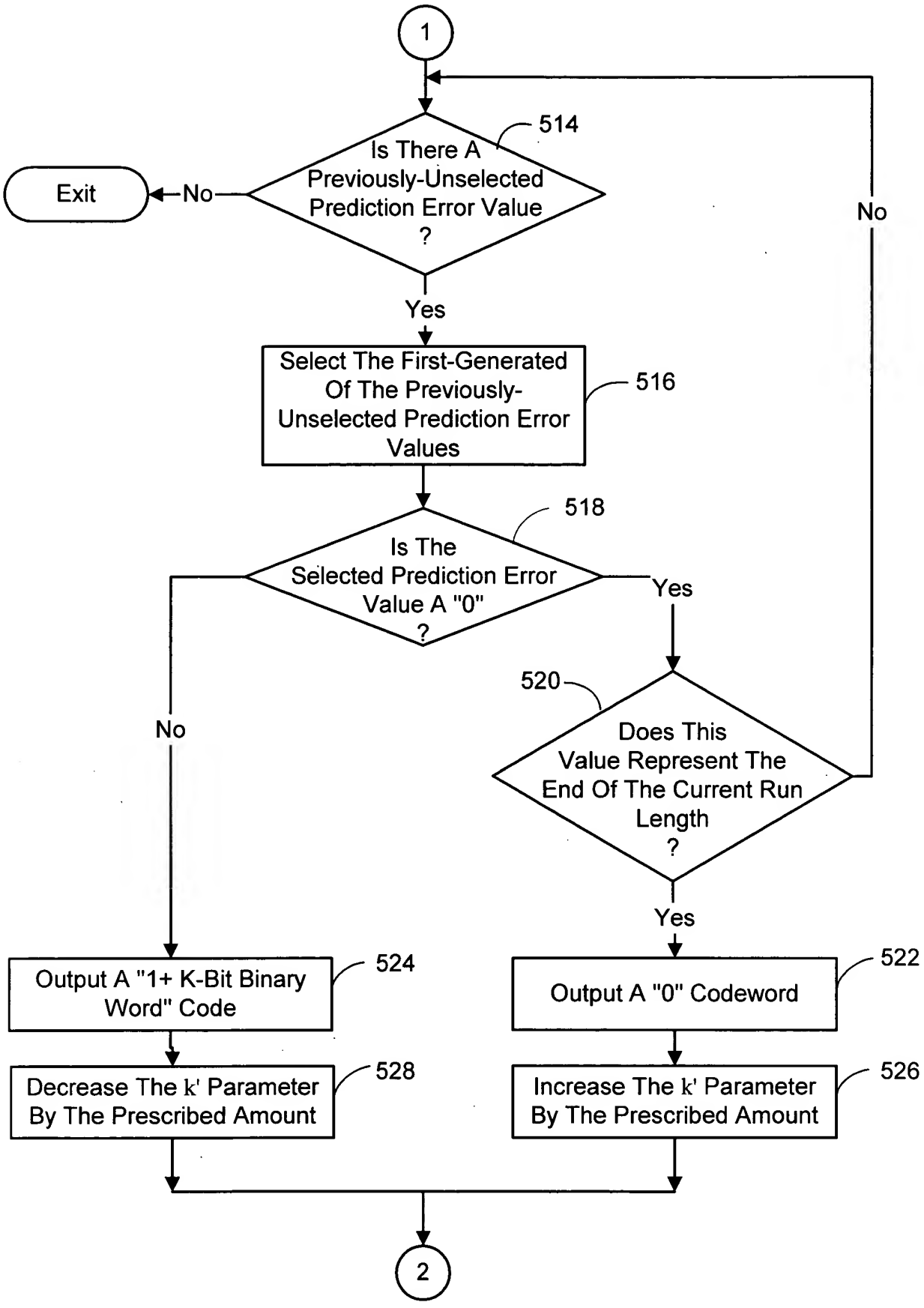

1
514
Is There A Previously-Unselected Prediction Error Value ?
Exit
No
No
Yes
Select The First-Generated Of The Previously-Unselected Prediction Error Values
516
518
Is The Selected Prediction Error Value A "0" ?
Yes
No
520
Does This Value Represent The End Of The Current Run Length ?
Yes
Output A "1+ K-Bit Binary Word" Code
524
Output A "0" Codeword
522
Decrease The k' Parameter By The Prescribed Amount
528
Increase The k' Parameter By The Prescribed Amount
526
2

FIG. 5B

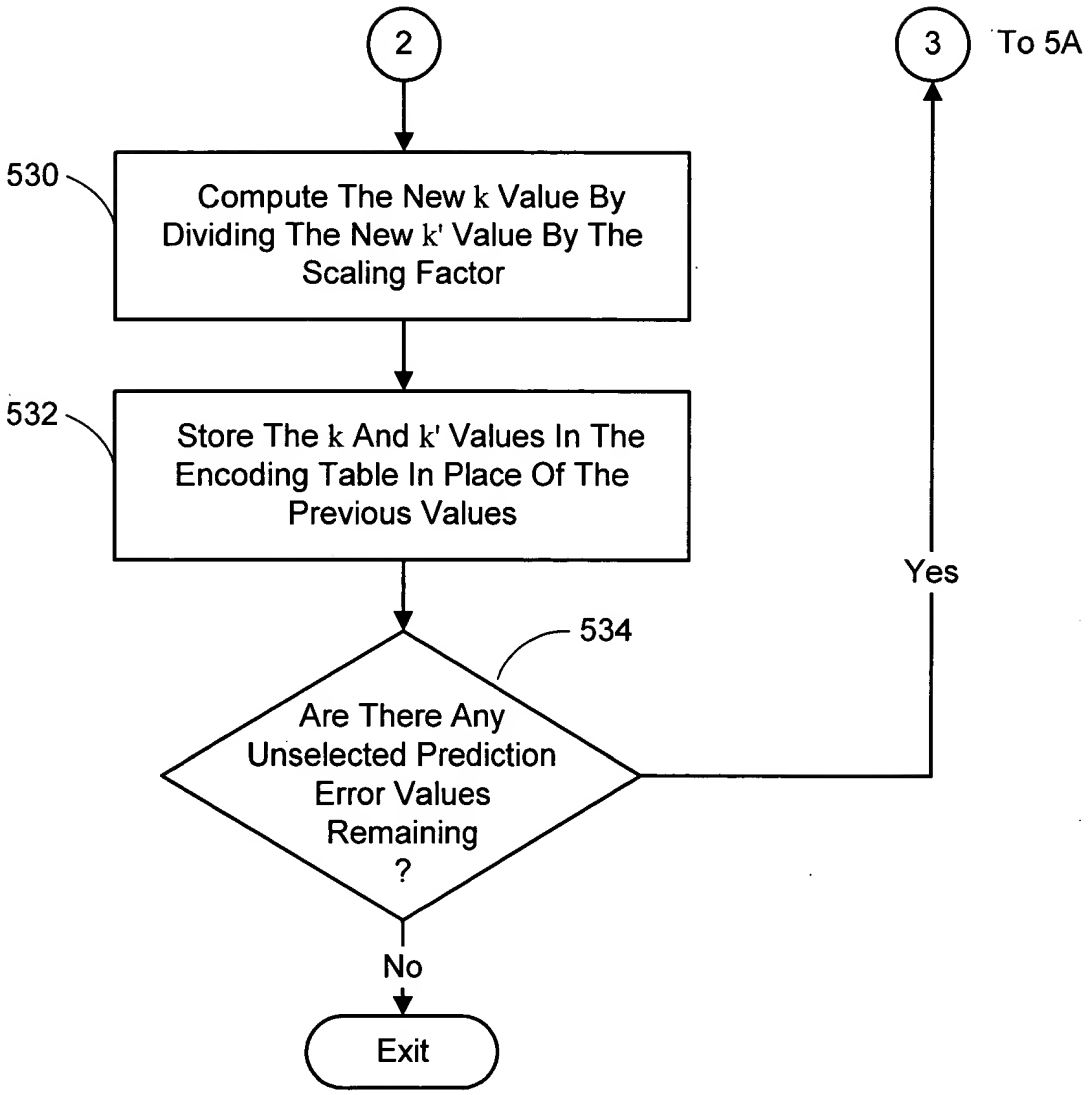

2
3
To 5A
530
Compute The New k Value By Dividing The New k' Value By The Scaling Factor
532
Store The k And k' Values In The Encoding Table In Place Of The Previous Values
534
Are There Any Unselected Prediction Error Values Remaining ?
Yes
No
Exit

FIG. 5C

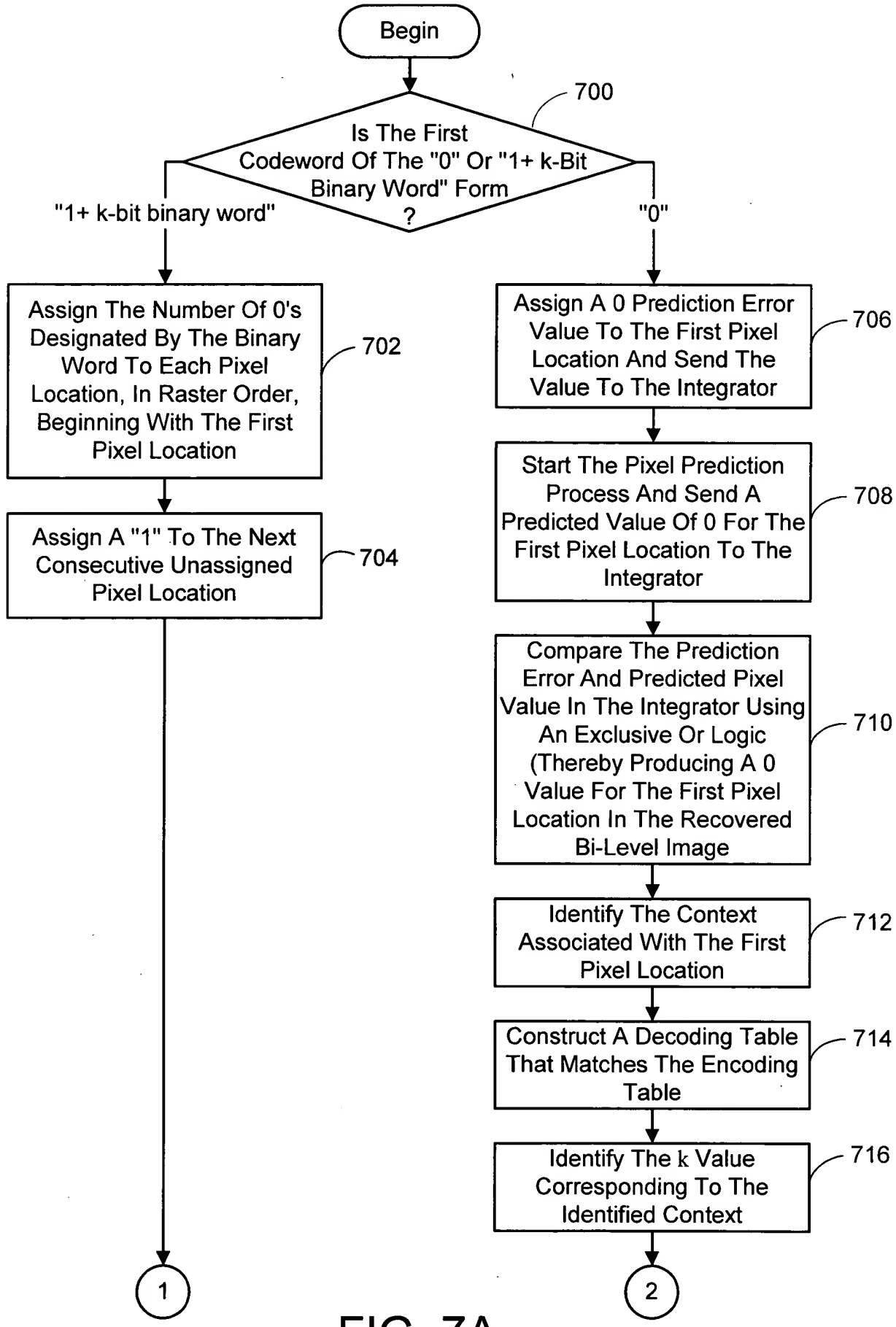

Begin
700
Is The First Codeword Of The "0" Or "1+ k-Bit Binary Word" Form ?
"1+ k-bit binary word"
"0"
Assign The Number Of 0's Designated By The Binary Word To Each Pixel Location, In Raster Order, Beginning With The First Pixel Location
702
Assign A "1" To The Next Consecutive Unassigned Pixel Location
704
Assign A 0 Prediction Error Value To The First Pixel Location And Send The Value To The Integrator
706
Start The Pixel Prediction Process And Send A Predicted Value Of 0 For The First Pixel Location To The Integrator
708
Compare The Prediction Error And Predicted Pixel Value In The Integrator Using An Exclusive Or Logic (Thereby Producing A 0 Value For The First Pixel Location In The Recovered Bi-Level Image
710
Identify The Context Associated With The First Pixel Location
712
Construct A Decoding Table That Matches The Encoding Table
714
Identify The k Value Corresponding To The Identified Context
716
1
2

FIG. 7A

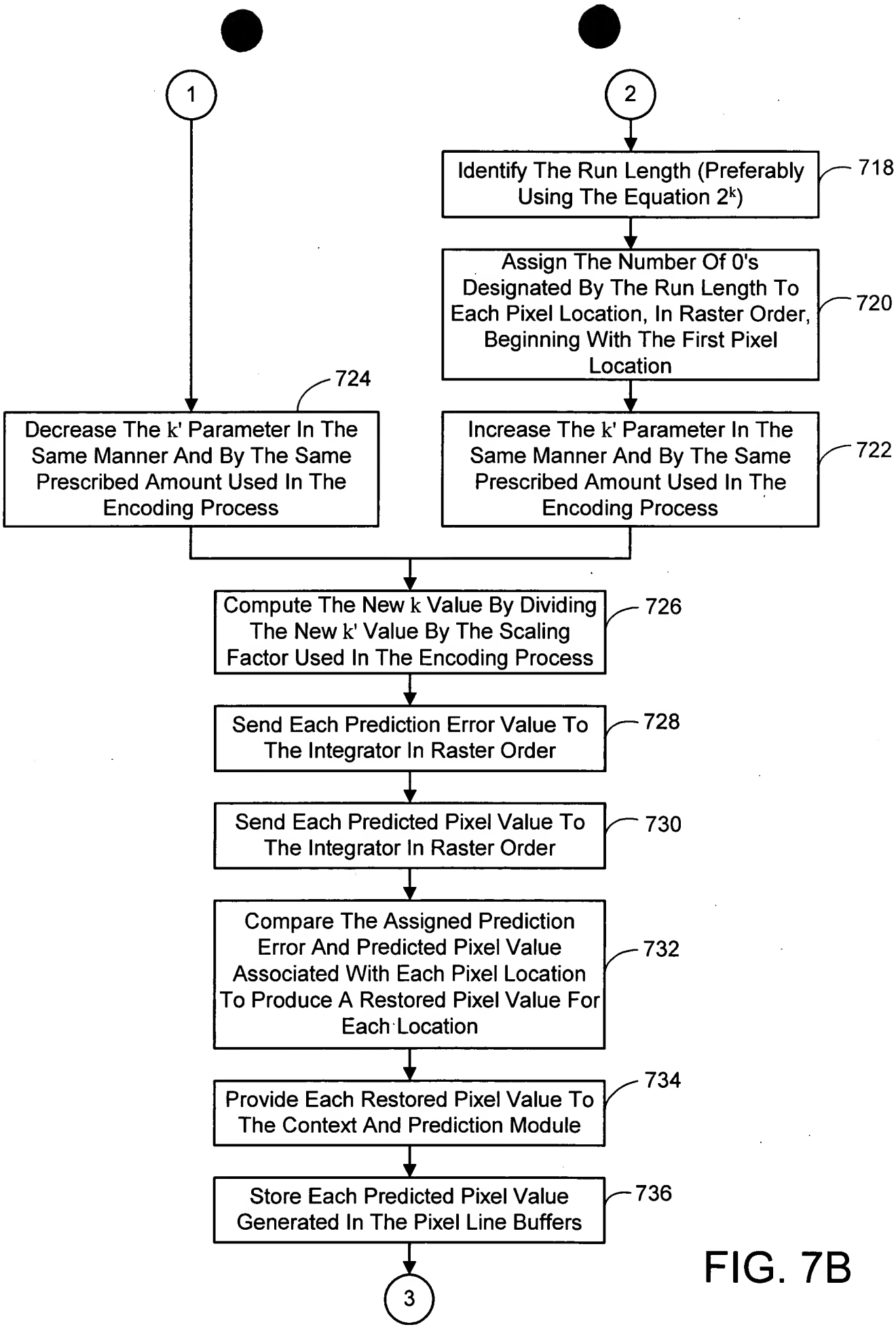
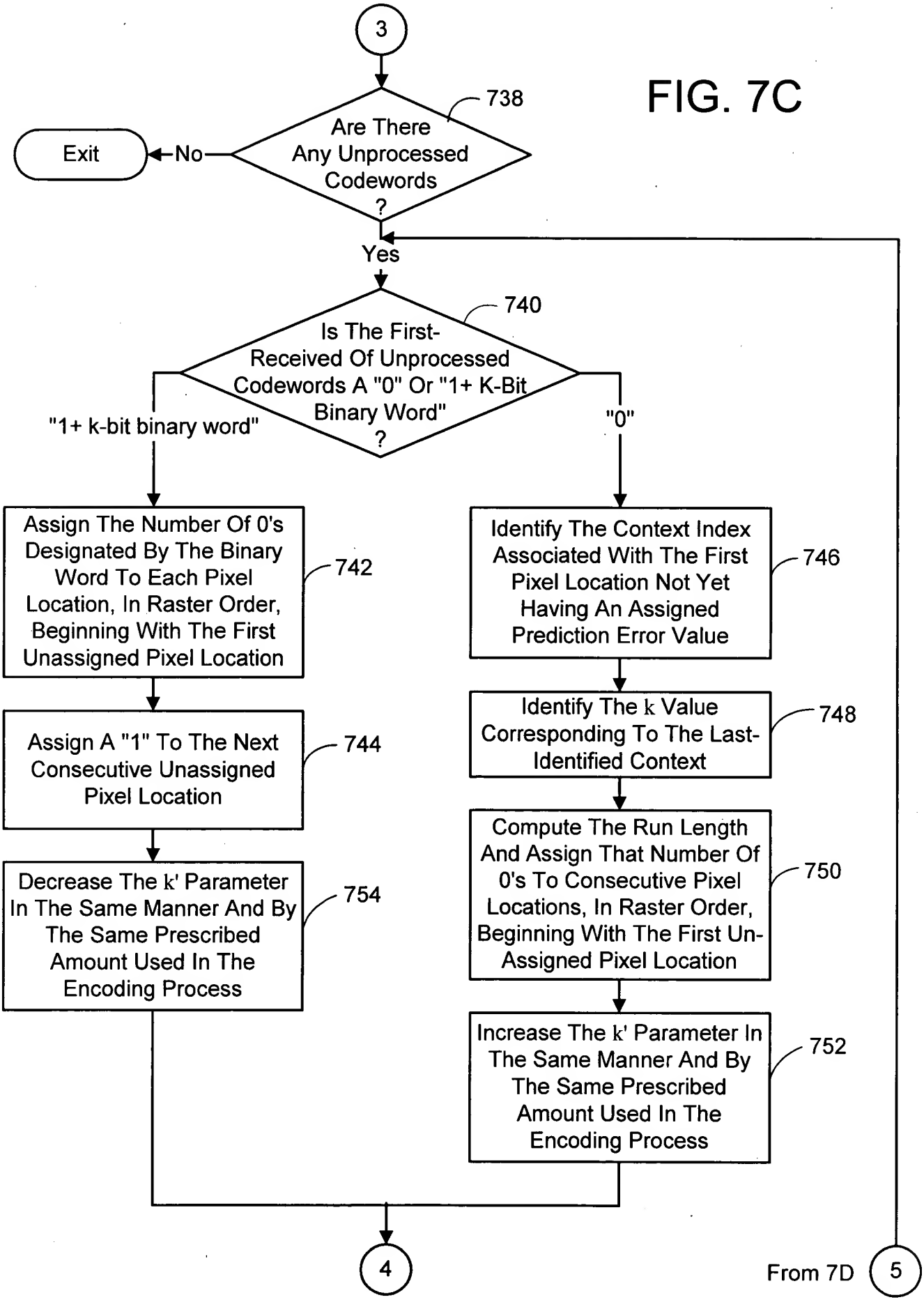

1
2
Identify The Run Length (Preferably Using The Equation $2^k$)
718
Assign The Number Of 0's Designated By The Run Length To Each Pixel Location, In Raster Order, Beginning With The First Pixel Location
720
724
Decrease The k' Parameter In The Same Manner And By The Same Prescribed Amount Used In The Encoding Process
Increase The k' Parameter In The Same Manner And By The Same Prescribed Amount Used In The Encoding Process
722
Compute The New k Value By Dividing The New k' Value By The Scaling Factor Used In The Encoding Process
726
Send Each Prediction Error Value To The Integrator In Raster Order
728
Send Each Predicted Pixel Value To The Integrator In Raster Order
730
Compare The Assigned Prediction Error And Predicted Pixel Value Associated With Each Pixel Location To Produce A Restored Pixel Value For Each Location
732
Provide Each Restored Pixel Value To The Context And Prediction Module
734
Store Each Predicted Pixel Value Generated In The Pixel Line Buffers
736
3

FIG. 7B

FIG. 7C


3
738
Are There Any Unprocessed Codewords ?
Exit
No
Yes
740
Is The First-Received Of Unprocessed Codewords A "0" Or "1+ K-Bit Binary Word" ?
"1+ k-bit binary word"
"0"
Assign The Number Of 0's Designated By The Binary Word To Each Pixel Location, In Raster Order, Beginning With The First Unassigned Pixel Location
742
Assign A "1" To The Next Consecutive Unassigned Pixel Location
744
Decrease The k' Parameter In The Same Manner And By The Same Prescribed Amount Used In The Encoding Process
754
Identify The Context Index Associated With The First Pixel Location Not Yet Having An Assigned Prediction Error Value
746
Identify The k Value Corresponding To The Last-Identified Context
748
Compute The Run Length And Assign That Number Of 0's To Consecutive Pixel Locations, In Raster Order, Beginning With The First Un-Assigned Pixel Location
750
Increase The k' Parameter In The Same Manner And By The Same Prescribed Amount Used In The Encoding Process
752
4
From 7D
5

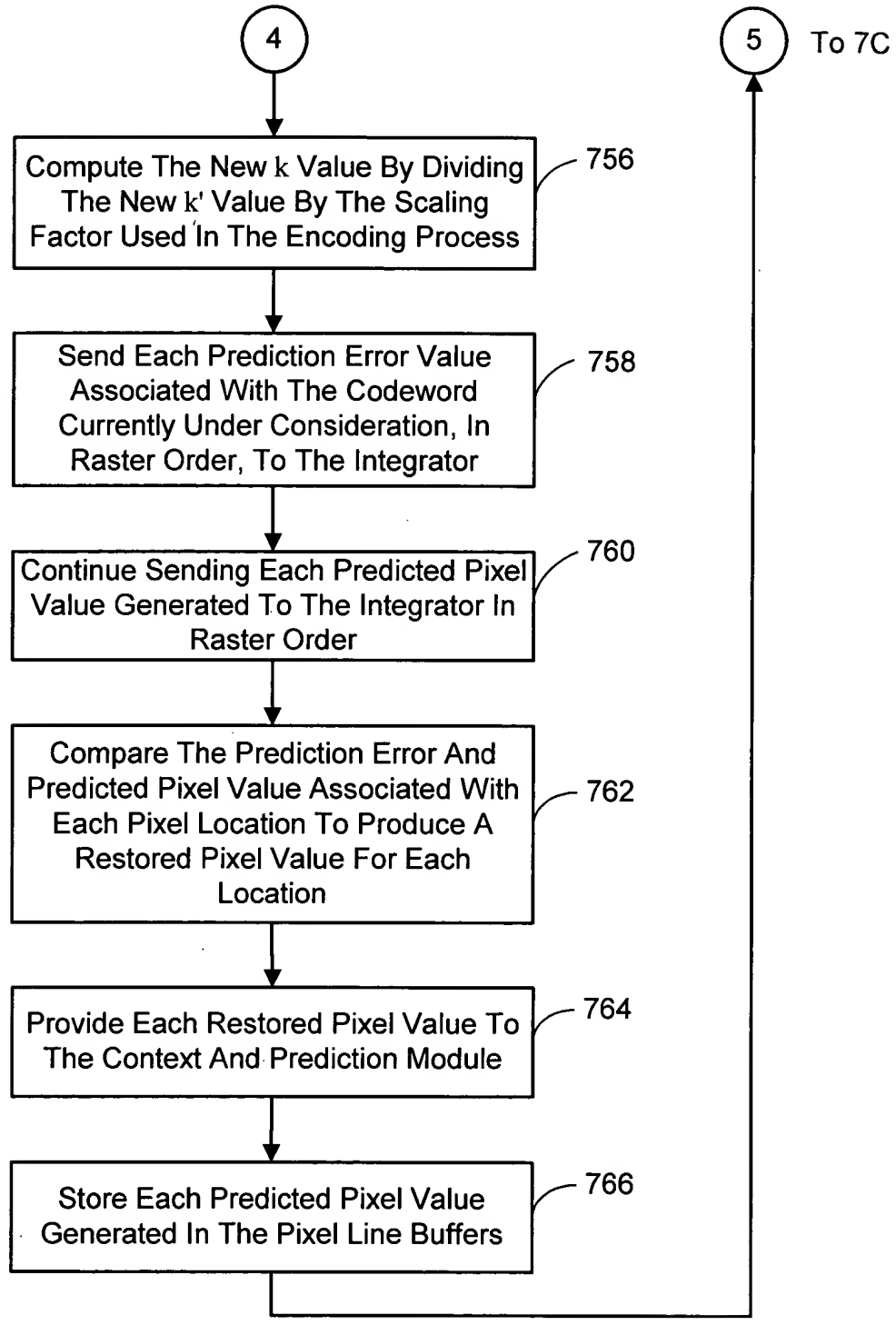

4
5
To 7C
Compute The New k Value By Dividing The New k' Value By The Scaling Factor Used In The Encoding Process
756
Send Each Prediction Error Value Associated With The Codeword Currently Under Consideration, In Raster Order, To The Integrator
758
Continue Sending Each Predicted Pixel Value Generated To The Integrator In Raster Order
760
Compare The Prediction Error And Predicted Pixel Value Associated With Each Pixel Location To Produce A Restored Pixel Value For Each Location
762
Provide Each Restored Pixel Value To The Context And Prediction Module
764
Store Each Predicted Pixel Value Generated In The Pixel Line Buffers
766

FIG. 7D

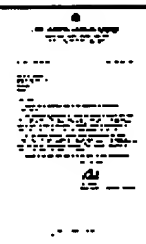
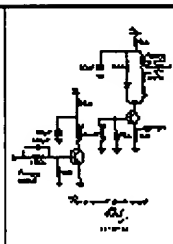
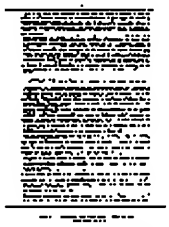
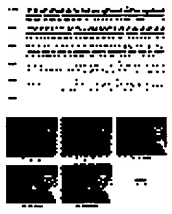
| Image |  |  | |  | |
|---|---|---|---|---|---|
| Dimensions | 1728 x 2339 | 1728 x 2339 | 1728 x 2339 | 1728 x 2339 | 1728 x 2339 |
| G3 | 33,450 | 33,380 | 58,384 | 96,106 | 60,956 |
| G4 | 17,994 | 11,364 | 26,860 | 67,664 | 30,970 |
| BLC | 12,943 | 8,081 | 19,964 | 48,722 | 23,224 |
| JBIG | 12,732 | 8,140 | 19,982 | 48,171 | 23,442 |
| JBIG-2 | 12,858 | 7,882 | 19,404 | 46,321 | 22,569 |
| JB2 (DjVu) | 9,606 | 8,697 | 16,820 | 29,480 | 18,230 |
| **Image** | | | |  | **Total** |
| Dimensions | 1728 x 2339 | 1728 x 2339 | 1728 x 2339 | 1728 x 2336 | |
| G3 | 49,074 | 103,164 | 61,732 | 151,102 | 647,348 |
| G4 | 16,706 | 71,674 | 19,004 | 138,146 | 400,382 |
| BLC | 11,913 | 52,683 | 13,386 | 61,183 | 252,099 |
| JBIG | 11,771 | 52,106 | 13,993 | 63,886 | 254,223 |
| JBIG-2 | 11,680 | 50,958 | 12,850 | 51,531 | 236,053 |
| JB2 (DjVu) | 13,011 | 38,295 | 14,504 | 58,624 | 207,267 |

FIG. 8

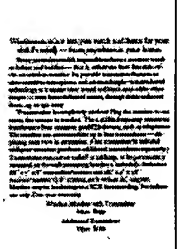
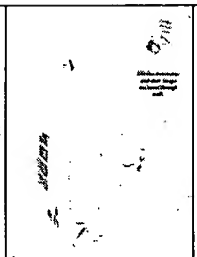
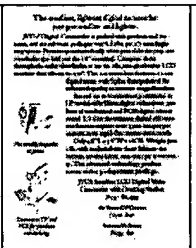
| Image |  |  |  | | Total |
|---|---|---|---|---|---|
| Dimensions | 1176x1552 | 1164x1548 | 1140x1544 | 1192x1540 | |
| G3 | 47,290 | 11,884 | 48,390 | 18,250 | 125,814 |
| G4 | 26,182 | 4,444 | 26,714 | 9,776 | 67,116 |
| BLC | 19,746 | 3,335 | 20,477 | 7,420 | 50,978 |
| JBIG | 21,221 | 3,754 | 21,694 | 7,774 | 54,443 |
| JBIG-2 | 19,744 | 3,584 | 20,497 | 7,628 | 51,453 |
| JB2 (DjVu) | 24,793 | 3,751 | 25,291 | 8,219 | 62,054 |

FIG. 9